resulting conflict Science has triumphed, and the Church, compelled to accept the newly discovered truth against her will, has in after years, claimed credit for being the educator and civilizer of nations. Modern civilization, dating from the triumph of the Copernican idea of the solar system, in all its distinguishing features, is the product of scientific research. Christian opinion has been kept busy, first opposing, and then trying to catch up. It has ever been and now is hopelessly in the rear. Driven from one position, it takes up the one nearest the one proven to be false, only to be obliged to abandon that in its turn. In its strange over-estimate of the relative importance of human beings and their notions or beliefs, it has utterly failed to get a correct understanding of the real character and meaning of the operations of Nature. In these days, in place of physical torture and the fagot, we have for Freethought and free expression, for ultimate scientific conclusions ;—the persecution by social and political ostracism, the boycotting of business men, and the insidious attempts to control the state and schools. Such persecution is the evolved natural product of the intolerance that in the early Christians led to the martyrdom of Hypatia, Bruno, Servetus, and thousands of others.

A good reason why the punishment for heresy is less severe than formerly, is that the churches lack power. In the interest of Science, liberty and safety, their power for evil should not be prolonged by resources drawn from the state, nor by contributions from liberal minded persons.

The refined persecutions by the churches is to-day so potent, that men in business or in politics ; or those desirous of social recognition, or of amassing wealth, often keep closed mouths, or conform to views and

customs they have outgrown. We have, thanks to Science, at last outstripped the ancients in everything, excepting religion. Orthodoxy, grounded in supernaturalism, still adheres to its idols. Christianity in nearly 2,000 years has given the race less of value than pure Science unaided and often opposed has done in the last half of the present century. Why do we still cling to the dead theological limb on the tree of human evolution? We of this generation have a duty to perform for those who come after. Majority rule is the pruning-saw. Let the dead and burdensome limb be severed near the trunk, that the world may have peace and progress.

Any intolerance toward innocent Christians should be avoided. Neither do wrong nor suffer wrong. It is only necessary that we should have the courage of our convictions, and reason will assert itself and truth and right will prevail. It can no longer be doubted that all the principles of natural selection have been in operation during the historical period, and the result has been, that taken as a whole, there has been decided progress. It is further evident that the greatest advance has been made at times when Nature has been the most carefully studied, and her mandates obeyed. The human race has improved physically, mentally, and morally.

Faith accepts the old creed or the old plow without question. Doubt leads to investigation, then experiment, and something better is discovered. This is the method of Science. It has given mankind during the historical period, through progressive improvments, in place of the old wooden plow—the steel and the steam plows. Note the evolution from sickle and threshing-floor to reaper and harvester; from quill-pen to type-writer; from the hieroglyphics of Babylonian pressed bricks to the perfecting printing press; from the crude steam engine of

Hero to the modern steam engine; from the mounted courier to the telegraph and telephone; from the wooden cart to the equipped railway; from the galley propelled by oars to the ocean steamer and the battleship; from the hand-loom to the power-loom; from a simple lens to the achromatic telescope and the compound microscope; from the tallow candle to the electric light; from the stage-coach to the electric cars; from the sword and javelin to the machine gun; from manuscript to newspaper, magazine and book, and so on indefinitely.

Very great advance has been made upward from the mire of superstition. We have reached the dawn of a new era. Let it be recognized. The present chronology, founded in mystery and superstition, is unworthy of this age. There should be no man, creed, or nation so highly honored as to mark the commencement of a new era. It should commemorate the work of the race, and be an earnest of the future. I venture to suggest that the year 1901 would be in several respects the best and most convenient time to make the change. Sooner or later it is bound to come. The year A. D., 1901, by dropping the first three figures, passes easily and naturally into S. E. 1, the first year of the proposed Scientific Era. The current year might be designated B. S. E. 3.

Closing our eyes does not dispose of the fact that a new and better period than mankind has ever known is at last in sight. The frightened, like the pursued ostrich, have the privilege of hiding their heads. The wise will gladly greet the rising light.

CHAPTER XIV.

CRYSTALS AND INORGANIC COMPOUNDS.

WE cannot become too familiar with the methods of Nature, whether on an extensive scale, or, as is often more instructive, on a minute or microscopic scale. The movements and combinations of atoms and molecules, small when individually considered, certainly determine the ultimate character of the greatest results.

However difficult of explanation we may think the various phases of organic nature to be, the operations going on in inanimate matter are scarcely less complicated and wonderful. The powers and properties of matter are closely allied, or identical throughout the mineral, vegetable and animal kingdoms. Any apparent gaps in the uniformity of Nature are illusions arising from our own imperfect knowledge. Every advance in knowledge has helped to fill such gaps, until, as we now survey the field no impassable ones are discernible. All the probabilities are in favor of continuity.

The growth of a crystal shows as much selection, skill and uniformity as the growth of the siliceous shell of a diatom,—and the affinity is close. Matter subjected to the subsidence of heat energy, to cooling off, changes from the gaseous to the liquid form, and then from the liquid to the solid through crystallization. Solids are also sometimes formed by direct crystallization from vapors. On cooling or evaporating a saturated solution, crystals must be formed, and they will vary in character accordingly as the conditions are changed.

Each mineral species has its characteristic form of crystals, which never vary when formed under the same conditions. The addition of a trace of some other substance, or an attempt to hasten the process will be seen in the product. It is easy to obtain characteristic crystals of most substances for examination with moderate microscopic powers. They are beautiful and instructive objects, and will well repay the student.

Common salt, crystallizing from pure water, takes the form of cubes by slow evaporation; and by rapid evaporation, hollow, four-sided pyramids. Sugar crystallizes in four-sided prisms, or it may remain for a time in an amorphous or uncrystallizable state. Sulphur may be soft and amorphous, or in crystals; or, when sublimed and condensed from its vapor in closed chambers it consists of minute globules, from a two-hundredth to a thirtieth of an inch in diameter. Beautiful arborescent forms of metallic silver crystallize around a bit of copper placed in a solution of nitrate of silver. Similar forms simulating vegetation may be had in gold from a solution of the chloride, or in lead from a solution of the acetate.

On the frosted window we have ready-made arborescent forms from aqueous vapor, and in the snow a great variety of star-like, six-sided, six-armed, beautiful, compound crystals. Water, therefore, crystallizes in hexagonal, stellar forms, and in ice the individual crystals are blended and continuous. Inhabitants of the Torrid Zone are slow to believe that water ever can become solid. In fact, one of the most reasonable places to introduce a special miraculous creation in all nature is at the origin of the crystal. Yet, familiarity with it has brought us to look upon it as perfectly natural. Alum crystallizes in regular octahedrons, consisting of two four-

sided pyramids united base to base ; gold in octahedrons, dodecahedrons, as well as in arborescent, spongiform, reticulated, filiform and acicular shapes ; quartz in hexagonal prisms with pyramidal terminations ; mercury in octahedrons, and iodine in rhombic crystals. We cannot here give more than a glimpse at the science of crystallography, only enough to call attention to the variety and perfection of form and structure in inorganic nature.

Who has not looked with wonder at large crystals like those of quartz and potassium-nitrate. A single crystal of quartz has been known to weigh 800 pounds. Large crystals have grown slowly because the supply of crystallizing material was gradually introduced and kept up for a long time. The material attaches itself to crystals already started instead of starting new ones.

Place a drop of the solution of ammonic chloride (sal-ammoniac) on a glass slip in the microscope. Small particles appear, and from these the crystals shoot out, forming beautiful branches, the secondary branches forming always at right angles, or at an angle of 45°, with the main branches. Solutions of urea, or of camphor, in alcohol give instructive crystallizations. As we watch the movements and the display of the building power of crystallization, we recognize the fact that there are other forms of life, rather closely related to plant and animal life, and often taking similar forms. The highest effort of plant life is the production of the flower, yet, how close a copy has inorganic nature set in the wonderful hexagonal ice-flowers and snow-crystals.

We are apt to lose sight of the capabilities of matter. Take the lightest known substance, hydrogen, an inflammable gas, and oxygen, a gas sixteen times heavier, that will not burn, itself, but is the feeder of combustion ; then chemically unite the two, eight parts of oxy-

gen to one of hydrogen and the result is water, the principal constituent of our own bodies. Think of the many properties of water. Pure white sugar consists of water, and carbon in the form of charcoal, chemically united, the product bearing no resemblance to its constituents.

Carbon occurs in several forms, in the diamond, coal and graphite. It is combined with oxygen in carbonic dioxide, the chief food of plants. It is decomposed in the leaves by the action of the Sun, the oxygen going into the atmosphere and the carbon becoming part of the plant. The great energy required to cause this separation of the two elements is stored in wood and coal to be given out in heat when they are burned, that is when their atoms of carbon are again being united with oxygen.

The chemical changes in high explosives, suddenly expanding them into gas and liberating their energy, attest the importance of atomic separation and combination, and the energy of matter that to an ignorant observer might be considered as inert.

The character of a mass of matter depends upon the quality and combining powers of its constituent chemical atoms. As we approach the higher and more complex combinations, qualities reminding us more and more of the peculiarities of living matter are manifested.

Of all the elements, carbon enters into more known compounds than any other. It is a many sided substance. Its compounds not only present different qualities, owing to the combinations of its atoms with the atoms of other elements, but the atoms arranged in different order produce dissimilar results. The carbon atoms possess the peculiar power of combining among themselves to an indefinite extent. Each of the com-

pounds may be modified by combination with other elements. So we have an indefinite number of combinations of which this remarkable element is capable. In this respect no other substance approaches it. We are prepared then to recognize the significance of the fact that it furnishes the foundation for the gathering together of the elementary substances necessary to the formation of organic compounds.

The carbon compounds form the bridge connecting the organic and inorganic. Over it matter has ascended from its highest mineral state to the lowest vegetable and animal, or protistic plane. Unstable chemical compounds have become a step more complex and vital activity has resulted. However, in its ultimate analysis, that which we call life or vital force, is but another form of chemical, or in a larger sense physical energy.

Organic compounds such as the coloring principle of madder root, have been, of late, made artificially by the chemist in his laboratory, by the combination of the atoms of their constituent elements. Hundreds of substances have been constructed in a similar way.

Living organisms are made up largely of water, and are therefore supplied with the best medium to encourage the free movement of atoms and molecules. Without this, whatever the possibilities of the other substances, life could not exist. The right degree of fluidity is as necessary as the proper chemical and thermal conditions.

A drop of water, oil, or other fluid, left free, will soon be covered with a pellicle formed under the same laws as govern the development of cell walls.

CHAPTER XV.

HOW ORGANISMS GROW.

IN commencing the study of mathematics, mechanics, or any branch of knowledge, we could have no hope of success unless we began with simple problems and worked upward by degrees to the complex. Following this time honored practice we have reached the consideration of the higher mineral compounds and have thus led up to the formation of another chemical compound, perhaps a trifle more complex,—the chemical action, manifestations and properties of which we call life.

The form of matter in question is called Protoplasm, from the Greek *protos*=first, and *plasma*=anything formed or moulded. All living beings of which we have any knowledge have been formed from this peculiar substance, and it is therefore worthy of our most careful study.

When a certain point in the cooling off of the Earth was reached, under the conditions then prevailing, two volumes of hydrogen united with one of oxygen and the vapor of water was formed. There was a point reached, in all probability, later, when the conditions were such that carbon, oxygen, nitrogen and sulphur, in certain proportions united to form Protoplasm. All the conditions necessary to such result may never have again been simultaneously present. The properties of Proto-

plasm are perhaps still more wonderful and difficult to understand than those of water, but they are none the less natural and illustrative of the laws of cause and effect.

Protoplasm is a homogeneous, slime-like, jelly-like, albuminous substance, in its simplest form showing no structure under the highest microscopic powers. This delicate substance, coming into existence in the Archæan era, a period covering more than one-half of geological time, and whose rocks have been altered by heat, it could not of course be preserved in a fossil state. All fossils represent its later and more mature work,—the chambers, shells and bones it has secreted and produced.

Living Protoplasm, in a form as simple as we can well conceive of, still exists and can be studied at leisure under the microscope. It is in little masses, individually visible with low powers, and satisfactorily seen with the higher powers of the instrument. These little bodies are called by Haeckel, Protamœbe primitiva. They are homogeneous, without organs, nuclei, or cell-wall; lumps of formless, transparent slime, semi-fluid; yet possessing powers of sensation, nutrition, motion and propagation; all in a very slight or primitive degree, yet, no doubt higher in these respects, than the original primordial forms.

Let us put a thin film of rich pond water on the slide, with a thin glass cover, and after hunting it up with a low power, use our best microscope lenses to study the little Moneron, a true Protamœbe primitiva, and then write down our observations. The uniformity of its substance is evident, and it looks very much like a watery fluid, resembling inorganic matter more than organic. It has no organs of sensation, locomotion, nor

digestion. Its form is constantly changing as different parts of its mass are extended and contracted. For this, or any purpose, one part of its substance is just the same as any other. Where now is an indentation, a minute later may be a projection. These motions seem slow enough; but they are in fact a thousand times slower than they seem to be, if we are using a power of 1,000 diameters, for the motion is magnified the same as the object. The visible results of the action of the Prot-amœbe upon its environments and they on it are also that many times less than they seem to be. We are apt to overlook the fact that we are witnessing after all an exceeding small degree of vital activity. When we realize this fact, and fully comprehend the simplicity of the living being, we recognize the truth that with such matter life on our planet began.

The boat shaped objects that often in moving about strike against our Moneron, are unicellular plants called diatoms. The empty shell of a diatom is smooth and free of protoplasm, and slides away from the Moneron; many live ones by a little jerking motion happen to escape; but finally one sticks fast and is slowly surrounded and enclosed in the little lump of living jelly. After the protoplasmic part is assimilated the siliceous shell is rejected. Yet, the little being is not, strictly speaking, organic. It has no mouth, eyes, stomach, heart, nerves, or any organ whatever. It moves along slowly by means of the extensions and contractions of its substance, which by courtesy we might call pseudopodia. In its wanderings a pseudopodium happens to stick through a tiny opening in the debris with which the water abounds. More of its matter flows through. Flowing is the word that seems best to describe its motion. Finally there is a

bunch of its substance on each side of the obstruction, connected by a thin isthmus. It parts, and the two halves go their ways two distinct beings, possessing all the properties of their parent. I have myself witnessed the primitive method of fission I have attempted to describe.

Such divisions, at first caused by the conditions of existence, proving advantageous, finally become fixed habits or characteristics. Whatever the true explanation may be, the fact remains that all the qualities of this simple being are retained and transmitted with the same conservatism as that which we have observed in the forms of crystals. We have to deal with the same forces under slightly changed conditions—and different chemical combinations.

As both the plants and the animals have developed from Protoplasm, it is probable that the amœbæ are also capable of taking their food after the manner of plants, in the liquid form by diffusion. This quality is not entirely absent even among the higher animals.

A number of species of the Monera have been described, and intermediate species connect them with a species of amœbæ, naked and having the motions of the one above described, but possessing nuclei. The nucleus is a globular lump of plasma containing a speck, —the kernel or germ, and is a condensation and differentiation of the same plasmic matter. It also propagates by division. When it passes into its resting state the pseudopodia are drawn in, it forms a globule, and secretes around itself a protecting membrane. Other little plasmic bodies taking their food in the same way secrete permanent shell-coverings ; some of them are, like those of the Arcella, very curious and beautiful. The shell of the Difflugia is composed of small stones.

When the amœba assumes its resting form, we have the primitive representation of the ovum as it first forms in animals and plants—from man downward; and this is not all, we have also a perfect *cell*,—and all plants and animals are either single cells or aggregations of cells. Neither is this all, we have in it a form intermediate between vegetable and animal. If its cell wall is tough and unyielding it has to receive its nutriment by absorption and diffusion like plants. In its naked form it incloses and digests its food. Hence, almost at the start the animal and vegetable kingdoms diverged from a common protoplasmic stock.

In the drop of pond or sea water are many animalcules composed of single cells,—with parts more or less differentiated through the advantages arising from the division of labor. Such functional division being of use to the little being, is the cause of the development of organs fitted to special purposes. The pseudopodia become modified into permanent cilia, the vibrations of which move the animalcule rapidly through the water; or, when feeding, create currents that bring its food into its mouth. From causes that are simple and obvious the development of the various organs goes on. To illustrate the position taken, examine with the microscope any of the ciliated infusoria, the Vorticella, and the Rotifera, when feeding. The microscopist will find no lack of objects illustrating all shades and grades of the primitive development of useful organs.

The capabilities of Protoplasm in its simplest forms are sufficient to justify all that is required of it in the development of the highest. Through adaptability and heredity its secretive skill has become wonderful. The shells of the Arcella and Diatomacæ should be examin-

ed with the microscope. See the wonderful variety of forms among the diatoms; the perfection of the boat-shaped, elliptical, circular, triangular, quadrangular, sigmoid and other forms. Increase the power and study the minute markings and skillful structure of the individual shells, rivaling the perfection of honey-comb—in the Triceratum favus and many others, and in all approaching the work of human designers. Remember that this is all done by single cells of soft, simple protoplasmic slime,—secreting these little boat-houses of silica in such perfect shapes—adapted to their needs and having the greatest strength with the least material.

The hexagonal and other geometrical markings of the diatoms are as true figures as are the same in the crystals of any minerals, and suggest a common parentage in the unity of matter and force.

The perfect work of cell-building and home-building matter is further exemplified in the Radiolaria. The protecting shell they build is remarkable for its beauty, strength and perfect adaptation. Yet, these organisms move through the water and feed by the aid of long, soft, slender, branching pseudopodia; being as evidently pure Protoplasm as the amœbæ. Others have connected, chambered structures like the Eozoon Canadense, a fossil already mentioned. The fossil remains of the shells of the Radiolaria and Diatomacæ make up in numbers what they lack in size, and form thick and extensive strata in some localities.

Much space might be taken up in describing the numerous interesting species belonging to the Protista, —like those we have mentioned, but they can only be really understood through direct personal observation. It may be said of this primitive kingdom of organisms,

that it is neither animal nor vegetable, but intermediate, and more primitive. Naturalists have not agreed in classifying the Protista, they having been claimed by both the zoologists and the botanists. They are all non-sexual. All the life they exhibit is caused by the chemical, electrical, metabolic and mechanical action —disturbing and changing the molecules of the sensitive Protoplasm.

"When the opponents of the Theory of Descent assert it to be miraculous and inconceivable that an exceedingly complicated, many-celled organism could in the course of time, have proceeded from a single-celled organism, we at once reply that we may see this inconceivable miracle at any moment, and follow it with our own eyes. For the embryology of animals and plants visibly presents to our eyes in the shortest space of time the same process as that which has taken place in the origin of the whole tribe during the course of enormous periods of time."—(Haeckel's *History of Creation*, Vol. II, page 40.

The Algæ being the beginning of distinctively vegetable life, furnish us with easy objects for the study of cells and their growth. There are numerous species both in salt and fresh water. They are easy for the beginner to recognize. The green scum on pools of standing water, and the green, hairy-like masses in running streams, and adhering to stones and logs, in ditches, swamps, ponds, springs and lakes, will be found to be nearly pure Algæ. Like the frost on the window, or the fern-like crystallization of metals, are the forerunners of higher vegetable forms as seen in the shapes of some of the lowest of these humble plants. This suggestive feature is seen in a few specimens not built up of cells, but composed of a single cell only; the

Protoplasm itself assuming by reason of hereditary adaptation the shape of a branching plant, with rootlets, stalk and leaves.

Scrape the green slimy coating from a stick that has lain for sometime in a pond, and perhaps several species of desmids may be obtained. With medium microscopic powers no more symmetrical and beautiful objects need be desired, though the wonderful growth displayed by each individual is accomplished by the tiny lump of Protoplasm in the single cell. When maturity is reached the cell divides through the middle and two desmids result.

Cells multiply by fission, or by the breaking up of the cell-contents into small spores. The long, hair-like Algæ are composed of single cells attached together in line. A cell divides transversely into two, each of the two divides making four, the four divide into eight, then sixteen, thirty-two, and so on, all remaining attached. This process may be watched in the microscope, and the movements of the Protoplasm and its granules are distinctly seen in each cell.

In other species the cells divide also at right angles with the primary division, one cell dividing into four, the four into sixteen, and so on, forming a square cellular surface instead of long filaments.

When gathering specimens do not pass by any patch of more than ordinarily dark green, for it may consist of Oscillatoria, the tubular cells of which form simple, rigid, elastic, moving, oscillating filaments that never fail to interest the observer. The Protoplasm of this genus of plants is very much alive, and the motions are decided—for organisms classed as plants.

The Protoplasm of vegetable and animal cells is the same substance—adapted to the different conditions of

their cell life. All plants are composed either of single cells or colonies of cells. Thin sections of any plant or wood are shown by the microscope to be built up of countless cells. In the bark, heart, and harder parts of trees the cells originally soft and yielding, have been changed by age or exposure.

The muscle, adipose tissue, bones, cartilage, crystalline lens, nerves, brain, every part of any animal or man is composed of microscopic cells. Each cell in its growing stage is a little lump of soft Protoplasm, retains its individual life, and has its life history. The large animal represents the aggregate life force, the united "bodies and souls" of its aggregation of individual cells. The cell is to the tree or man, that which the tree is to the forest, or the man to the state. Each man is a community of specialized cells, and each cell performs its part with the energy shown when life itself is to be preserved. It prospers or fails, lives or dies with its companions.

The white blood corpuscles of man and the higher animals are protean, have the characteristic movements of amœbæ, and take within their bodies food or particles of foreign substances the same as the amœba. They have been seen to take up fine particles of indigo that had been injected into the veins, and by removing them assist in purifying the blood. When the animal of which they are a constituent part is wounded, they gather at the injured spot and eventually heal the wound with their own bodies,—growing into the new flesh.

Cells originally of the same kind, under the operations of inherited tendencies, and the varying conditions and necessities of the parent organism become nerve cells, cartilage or bone cells, muscular fiber, cells of generation, mucous membrane, brain cells, anything neces-

sary to benefit the being to which they belong. Each is to the animal what the individual crystal is to the rock, or the single vegetable cell is to the plant. The work of each one is small; perhaps not greater than that of an unicellular diatom or desmid, but in the aggregate by reason of their immense numbers, and unity of action, great results are attained. A single grain of sand counts for naught, but millions make a mountain. If the number of coral insects be great enough—the coral reefs become important islands. In the animal and vegetable economy there is nothing so important as the cell. Its relation to biology is the same as that of the crystal to mineralogy.

The ovum of any plant or animal is at first a single cell—a cell of generation. All the way along the tree of life and out upon its branches the ovum is so simple a bit of Protoplasm that it is indistinguishable in the microscope from the still form of the amœba. Throughout all, the development from the ovum is by cell division,—and the cells go on and build up along the lines of growth inherited by the cell Protoplasm, with slight variations adapting the young being to changed conditions. In its growth each cell passes through all the intermediate forms from amœboid cell to adult animal or plant;—the same course its ancestors had traversed in geological time.

Out of millions of seeds scattered every year broadcast over the ground only comparatively a few germinate, survive and mature. Out of untold millions of organisms that started up from the primæval slime, only a few favored forms survive to our times. The vast majority dwindled away and perished early. The survivors represent those best fitted to their environments. The severity of the struggle is proved by the myriads of the species

slain, and the high degree of development reached among the survivors.

It has not been a chance evolution in any sense, but the strength acquired by use, and the greater immunity from danger which is the reward of adaptation, have through the laws of heredity caused a steady, slow, but sure progress in the properties of the cells and in the grandeur and perfection of their work.

As the moral and intellectual worth of the individuals united to form a republic is the measure of the national character, so is the quality of the constituent cells the measure of the physical and mental capacity of the man. Their fidelity to their inheritance is manifested in the true breeding of the species. Their plasticity is seen in their ready conformity to changed environment. Both qualities are in evidence from monad to man.

CHAPTER XVI.

EVOLUTION OF MIND.

WHERE does mental action begin? Shall we say that all organic beings having life, power of motion, or feeling, are therefore possessed in some degree of mental powers? We have seen that all the organisms, living and extinct, have developed physically from simple cells. Have the same processes of evolution also developed the mental powers from small beginnings? The protoplasm of all vegetable cells has life, motion, soul, and is unstable, tender, sensitive to environment and free to molecular changes. The Sensitive plant shrinks at a touch. The Drosera selects and digests animal food, and a number of plants have motion.

Among the Protozoa a gradation is observable from species having only the faintest signs of motion and life, to those possessing a considerable degree of activity. The action of their sarcode or Protoplasm in the lower forms is not distinguishable either in kind or degree from that of the protoplasmic contents of the plant cells.

In the Radiolaria, Arcella, Difflugia, and other more highly developed unicellular forms that may be classed as animals, the physical and mental action of the little mass becomes more marked. The pseudopodia are farther extended and with more evident design of obtaining food. Their extensions and contractions show evidence of purpose. It builds its exquisite shell-house, feeds, moves at will, and shrinks from danger.

We cannot truthfully affirm that this simple, homogeneous lump of slime does not possess mental attributes of a primitive order. In fact, the more the infusoria are carefully studied, the more firm must the conviction become that their mental sphere enlarges and keeps in exact touch with their physical evolution. The physical and mental adaptation to circumstances proceed in the march of development within every cell, fiber and molecule, interwoven and inseparable.

The cell, when forming a separate organism, develops mentally, as we can learn with the microscope, and the same means of investigation show the same results in the higher infusoria, and the aquatic larva of insects. Such animals, consisting of a number of cells, modified and adapted to perform different functions, may be found transparent enough for easy study. In all the numerous species, as in the Tardigrada, or bear-animalcules, advance in bodily perfection is accompanied by a nearer approach to the higher animals in all voluntary motions.

The long, slim pseudopodia of the rhizopod enable it to feel external objects, and a similar extension of the cell plasma of the multicellular animal enables impressions to be felt in other parts of its body. This is the beginning of nerve fiber. A cell located in the anterior part of the body, by greater use becomes a little more sensitive than the others and becomes the starting point of a cephalic ganglion, which becomes the principal seat of mental powers. These little animals, confined in the growing slide of the microscope and watched for some time, will show considerable ingenuity and persistence in their endeavors to obtain food or to make their escape.

All authorities recognize the cephalic ganglia of insects, and the brains of the higher animals, as being the organs

of their minds. That these organs are, like the muscles, decreased in power by disuse, and increased by use, cannot be denied. Not only this, but mental action continued indefinitely in certain lines, will increase in like manner the strength and facility of mental action in those special directions, accompanied by corresponding changes of brain. Such actions becoming habitual, and being performed involuntarily, are spoken of as instinctive.

Now, among insects, from the higher animalcules up to bees and ants, there has been in their cephalic ganglia an unbroken line of evolution. Note the large and finely developed heads of the ants. They have lived by their wits and their minds and heads have become comparatively large. They construct cities, lay up stores of food in good weather, keep domestic animals, carry on long and well conducted military campaigns, and are able to talk or communicate understandingly with each other. If the reader doubts, let him study them. If ants working at constructing a chamber in their hill, make a mistake, as they often do; the supervising ant architect, on noticing the error, has been observed to require the work to be torn down and built over again. This is reason, and does not differ in kind from the workings of the human mind. All the higher insects readily change their habitual actions to make them the better conform to different conditions.

Bees hold fast with their claws and use their wings, on sultry days, as fans, to produce cooling currents of air. They modify their combs to suit the shape of hive, or tree, or any intervening obstructions. Different species of bees make different shaped cells, and ingeniously select and improve their homes to suit their various requirements. Close observation shows that there is no

lack of variety of expedients among colonies of the same species, or even among individuals of the same colonies. They recognize and like their friends, but hate and sting their enemies.

The vertebrate animals vary in nerve and brain development,—from those having no brain, only a spinal cord, without important gaps, up to the large and complex human brain. All along the line the mental keeps step along with the physical evolution, and corresponds with environments. The mental attainments like the physical qualities have gradually built up by the addition of small gains, commencing with the craving for food. Improvement kept pace with the accumulation of experiences. The enlarged necessities resulting from the increase in numbers, and the consequent more intense struggle for existence, required and caused the growth of larger and better brains.

The average weight of brain (European, male,) is 49.5 oz., female, 44 oz. Among idiots, brains are found weighing from 27 oz. down to 15 oz., and even as low as 10 oz.

As a rule men of unusual ability have large brains. Cuvier's brain weighed 64.5 oz., and Daniel Webster's 53.5 oz. The weight of the brain of the horse is given at 23 oz., of a whale 5 to 8 pounds, of an elephant from 8 to 10 pounds. The intellect of a large fleshy animal like the elephant is not in proportion to the great size of brain, for the reason that a large portion of nerve force is expended in keeping up digestion, circulation, respiration, and the action of the muscles. It often happens that smaller brains make up in quality and activity what they lack in weight.

The brain material is the same in man as in the dog, cat, or other of the higher animals, both chemically and

microscopically. In its parts and structure it is also the same, but more highly developed.

The brain is composed of nerve fibers in some parts parallel and in others interlaced with crossing fibers, a white medullary substance, a gray cortical substance, and delicate supporting tissue. The white nerve-fibers are from 1-5,000 to 1-14,000 of an inch in diameter; the gray nerve-fibers about half as large; nerve-cells between 1-300 and 1-3,000 of an inch in diameter; and the nerve-granules 1.7,000 to 1-10,000 of an inch in diameter.

The number of nerve-fibers is enormous, the optic nerve containing not less than 100,000, and the white brain matter hundreds of millions. The brain-cells are round, oval, pear-shaped and radiating, granular and nucleated, and doubtless number as high as a billion in the average human brain. They are connected with each other by nerve-fibers, and all parts of the body are connected with them by nerves, each fiber of which is isolated by protecting coats, and passes without a break, to its own part of the brain. Thus each nerve-fiber conveys its own secret message to its nerve-center in the brain. Each nerve-fiber starts from a brain-cell which is also connected with other cells and fibers. Through the cell the in-coming and out-going nerves are connected. The nerve-fibers, branching along the smaller arteries to the capillaries, are continuous with the return fibers along the veins, thus completing the circuit of the nerve currents. There is a rather close affinity between nerve force and electric force. Any disturbance at an extremity affecting one set of nerves cannot be communicated across to other nerves, but must pass up the nerve-cables to the central office, the brain, and then out to other parts. Anything that stimulates to action a nerve-fiber anywhere in the body, produces cor-